RESULTS OF GEOLOGICAL INTERPRETATION OF SPACE PHOTOGRAPHS OF NORTHWESTERN LAKE BALKHASH AREA, TAKEN FROM ORBITAL STATION SALYUT

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Translation of: "Rezul'taty geologicheskogo deshifrirovaniya kosmicheskikh snimkov severo-zapadnogo pribalkhash'ya poluchennykh s orbital'noy stantsii "salyut", Academy of Sciences USSR, Moscow, Preprint, 1973, 9 pages

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
WASHINGTON, D. C. 20546 APRIL 1974

STANDARD TITLE PAGE

1. Report No. NASA TT F-15,553	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle RESULTS OF GEOLOGICAL INTERPRETATION OF SPACE PHOTOGRAPHS OF NORTHWESTERN LAKE BALKHASH AREA, TAKEN FROM ORBITAL STATION SALYUT		5. Report Date APRIL 1974 6. Performing Organization Code
7. Author(s) N. A. Yakovlev, Ye. A. Al'perovich and N. V. Skuvlova		8. Performing Organization Report No. 10. Work Unit No.
9. Performing Organization Name and Address TECHTRAN CORPORATION P.O. BOX 729 GLEN BURNIE, MARYLAND 21061		11. Contract or Grant No. NASw-2485 13. Type of Report and Period Covered Translation
12. Sponsoring Agency Name and Address NATIONAL AERONAUTICS AND SPACE ADMINISTRATION WASHINGTON, D. C. 20546		14. Sponsoring Agency Code

15. Supplementary Notes

Translation of: "Rezul'taty geologicheskogo deshifrirovaniya kosmicheskikh snimkov severo-zapadnogo pribalkhash'ya, poluchennykh s orbital'noy stantsii "salyut", Academy of Sciences USSR, Moscow, Preprint, 1973, 9 pages

16. Abstract

The capabilities of interpretation of space photographs of the Earth for obtaining new information of large features of geological structure are discussed by way of example of the northwestern Lake Balkhash region. The interpretation yields more information on fault structure than on other features, and also on regional features than on small details.

17. Key Words (Selected by Author(s))	18. Distribution Statement
	Unclassified-Unlimited

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	8	

RESULTS OF GEOLOGICAL INTERPRETATION OF SPACE PHOTOGRAPHS OF NORTHWESTERN LAKE BALKHASH AREA, TAKEN FROM ORBITAL STATION SALYUT

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Since the adoption of geological studies by aerogeological, geophysical /1* methods greatly increase the quality of geological photography operations, the effectiveness of investigation of the deep geological structure of forecasting and prospecting of resources. At the same time ever-increasing importance was attached to the problem of generalizing the assembled information and investigating regional and global principles of the geological structure and development of the Earth, which are the foundations for interpretation.

The solution of this problem involves certain difficulties related to the diversity and variable quality of existing geological data and absence of an objective basis for their summarization. The ordinary extrapolation method used for this purpose often leads to narrow, subjective and sometimes erroneous conclusions.

The experience that has been gained in recent years indicates that it is possible to use as a subjective base for regional and global geological constructions space photographs that have the required properties: great field of view and reflection of large features of the geological structure at the expense of generalization of fine points. Furthermore from the data of foreign (Lowman, 1966; Lowman, 1968, etc.) and Soviet (Gonin et al., 1969; Gonin et al., 1971; Artamonov et al., 1971) works show that the interpretation of space photographs produces a great amount of new information, which is an important addition to data gained from ground and aerogeological investigations. Thus the utilization /2 of space vehicles may be regarded as one of the new and independent means of investigating the geology of our planet.

In this connection the development of methods for using space photographs for geological purposes and for comparing their information content with materials

*Numbers in the margin indicate pagination in the foreign text.

of other methods, in particular with the previous high degree of remote investigations — small-scale aerial photography, is an urgent problem. The evaluation of the capabilities of the new method by way of example of such a complex and by now well-investigated region as the northwestern Lake Balkhash area, which was photographed from the satellite Salyut in June of 1971, is of unquestionable importance in this regard.

The northwest Balkhash area is located in the center of the Kazakh fold zone — at the juncture of the Kazakh Caledonian and Hercynian. It is characterized by a complex folded structure: parts made up of strongly dislocated Precambrian, lower Paleozoic and Silurian sediments, alternating with small sections and vast areas where moderately compressed Germanian folds are developed, formed by Silurian, Devonian, carboniferous and Permian sedimentary and igneous deposits. Much of the territory is comprised of outcroppings of numerous intrusions of primarily granitoid composition, rather uniformly distributed throughout the entire region. Tectonic faults, both large regional ones with an amplitude of up to 10 and more kilometers, extending for many tens of kilometers in the latitudinal or northwest directions, and small, variously oriented faults that impart a mosaic appearance to the tectonic structure, are extensively developed.

The tectonic structure of the northwestern Lake Balkhash area is a Hercynian structure, somewhat distorted by Mesocenozoic free block movements. /3 Its most important structure elements are Hercynian anticlinoria and synclinoria. The boundaries of the anticlinoria and synclinoria are usually large faults (Figure 1).

The main purpose of interpretation of space photographs (Figure 2) was to determine their information content in relation to the basic components of the geologic structure: lithological-petrographic rock complexes, plicate and disjunctive faults, and also specific volcano-plutonic structures of the central type, inherent to the region.

The capabilities of interpretation of the lithological-petrographic complexes were quite limited. Only strata and intrusive formations characterized by extensive fields of development and relatively "sharp" interpretation criteria are distinguishable and recognizable in the photographs.

Most distinctly seen in space photographs are detrital deposits of the Mesocenozoic and Permian granitic plutons. The latter are distinguished according to the characteristic network of cracks and, as a rule, the anomalous photographic tone of the image. However the photographic tone of the picture of granitoids may vary: from light grey (Bektau-Ata) to dark grey (Kent), which probably is related to the various density of the vegetation cover that has grown over them.

Igneous and sedimentary formations are considerably harder to interpret. Large fields of development of effusives of the Tokrauskiy synclinorium and Silurian and lower Paleogenic sedimentary rocks can be detected by photographic outline and tonality.

Interpretation of large plicate structures of the region, which is possible in individual cases, is directly related to weak interpretability of the lithologic-petrographic complexes. An example of such interpretation is the combining of the Kenterlauskiy anticlinorium and the Tokrauskiy synclinorium, made up of rocks with greatly different interpretation indices. Certain plicate /4 structures of high orders can be traced as layers, the outline of which is attributed to the sharp contrast of the photographic image of the alternating rock strata (superposed synclines in the western Balkhash synclinorium).

Most of the information is obtained during interpretation of space photographs concerns faults, which were the main content of the composite diagram of geological interpretation (Figure 3). The interpretation of faults is based on the structural control of relief features and erosion network, straight-line contour contacts, different in terms of outline and tone, and reflecting the differences of the rocks confined to them. By virtue of the characteristic feature of space photographs, namely field of view, it is possible to check extended faults, expressed by the diverse complex of features that are indicative of them, namely faults that alternate in terms of strike. The most important faults of the region are interpreted as follows: central Kazakh, Aktasskiy, Tokrauskiy, Zhamshinskiy, Uspenskiy faults and certain others. It should be pointed out that the expression of most of the interpreted faults of ancient, Paleozoic origin in relief is attributed to their more recent activation.

Data from the interpretation of space photographs make it possible to distinguish 4 fault systems: nearly latitudinal, northwest meridional, northwest and northeast. It is possible on the basis of their mutual displacement to establish the sequence of the most recent activation of each of the systems.

The oldest system is the nearly latitudinal fault systems, which requires a northwest orientation within the southwestern part of the region. The space photographs clearly show the Akzhal-Aksoranskaya and Akbastauskaya fault zones, the Atasuyskiy, Ergenektinskiy and other faults, which run parallel to them. Most of these fault systems are well charted as the result of ground geological observations and interpretations of aerial photographs. Some of them were indicated only by analysis of physical fields. /5

The effect of reflection through the 1 km thick effusives of the Tokrauskiy synclinorium of the southeastern extension of the Akzhal-Aksoranskaya fault should be regarded as an anomalous phenomenon that is observed in space photographs. The nature of this phenomenon, which has not yet been confirmed by geological data, can apparently be explained only by the most recent shifts in the ancient deposition zone. Examination of space photographs definitely establishes that the Akzhal-Aksoranskaya and Akbastauskaya fault zones run together in an area northwest of Bektau-Ata granite mountain and can be traced as a single zone through the entire Tokrauskiy synclinorium and Kentarlauskiy anticlinorium, passing beneath Lake Balkhash into the area between the village of Krasnyy Oktyadr' and Algaza Island. It should be pointed out that one of the faults of the examined system, located west of the Akzhal-Aksoranskaya zone, travels across the floor of Lake Balkhash into the southern Lake Balkhash area.

The meridial faults that run parallel to the central Kazakh fault displace the faults of nearly latitudinal strike. Many of the faults of this system are established on the basis of geological data; some of them were suggested to exist beneath the broken mantle of the Mesocenozoic as the result of analysis of physical fields. The Kokgal'skiy fault, which extends westward from Kyzylray Mountain, was detected as the result of ground geological observations only in the form of individual fragments; in space photographs it can be traced continuously for distances of about 200 km.

It can be assumed on the basis of space photographs that the latest shifts along the faults of northwest strike are more recent than along the meridial and nearly latitudinal faults. The stated faults, known on the basis of geological data to exist only within the eastern part of the region, were established in the western part only as the result of analysis of physical fields. The faults of this system are traced in space photographs as distinct /6 lines within our region.

The most recent tectonic shifts in this region probably occurred along the system of northeast of faults. According to geological data they are known to exist in the northern part of the region (the Uspenskaya fault zone, Uralbayskiy and other faults). Interpretation of space photographs establishes the extents and development of this system within the entire region. The longest faults are arc-shaped and their strike changes from nearly meridial in the south to nearly latitudinal in the north. Of particular importance among the faults detected by interpretation of space photographs is a fault that runs parallel to the Uralbayskiy fault, extending from the Baynarzarskaya circular structure to the north of Shaltaskiy granite mountain into Betpakdala, and also a fault that is traced from the shore of Lake Balkhash to Kyzyltis granite mountain, displacing the Bektauatnskiy intrusive. The stated faults were not established on the basis of geological data or as the result of interpretation of physical fields. All the faults of this system clearly displace all other faults (Figure 3).

The Paleozoic and more ancient plutonic structures of the northwest Lake Balkhash area which have experienced considerable denudation of erosion, are interpreted in space photographs on the basis of deep structural elements: chiefly intrusions of the central type and eroded extrusive domes, circular and radial faults, systems of ingrafted igneous strata, etc. These criteria are used for interpreting a whole series of circular systems measuring in diameter from 10 to 70 km, most of which coincide spatially with previously investigated circular plutonic structures (Kentskaya, Kyzylrayskaya, Kargalinskaya, Kyzyltyskaya, etc.). Circular structures that were not established on the basis of geological data and interpretation of aerial photographs are interpreted in

space photographs in rare cases (for example the structure in the Kyzyltau region, which imitates the contours of the Kyzyltauskiy gravitational minimum).

The interpretation of space photographs produces information primarily on /7
the large linear and concentric fault structures of the region. It not only confirms the existence of previously known regional faults, but also indicates their extensions and the presence of previously unknown strikes. The possibility of tracing disjunctives under detrital deposits, and sometimes beneath lithified overburdens, it is thereby established.

The comparison that is drawn here with data from the interpretation of small-scale aerial photographs indicates that the latter contain considerably more detailed information, but at the same time they do not capture certain regional elements that are easily interpreted in space photographs. Thus, these materials may be regarded as mutually complimentary for the purpose of analyzing the tectonic structure of large regions.

CAPTIONS TO FIGURES

Figure 1. Tectonic Chart of Northwestern Lake Balkhash Area. Constructed by Ye. V. Al'perovich on the basis of materials of V. P. Bespalov and V. I. Yagovkina. 1, Hercynian anticlinoria: I, Bulatauskiy; IV, Atasuyskiy; V, Atasu-Zhamshinskiy; VII, Zhaman-Sarysuyskiy; VIII, Novaly-Kyzylespinskiy; X, Kenterlauskiy; XIII, Tyulkulamskiy. 2, Early Hercynian synclinoria: II, Mynaral'skiy; III, Mointinskiy; VI, Akzhal-Aksoranskiy. 3, Late Hercynian synclinoria: IX, Tokrauskiy; XI, northern Balkhash; XII, Sayakskiy. 4, Regional faults.

Figure 2. Space Photograph of Northwestern Lake Balkhash Area, Taken from Orbital Station Salyut.

Figure 3. Interpretation of Space Photograph of Northwestern Lake Balkhash Area. I, Regional fault; a, previously known; b, presumed; c, newly discovered (I-Aktar-Sarytumskoye); 2, Kashken-Tenizskoye; 3, Oguzstauskoye; 4, Shalgiya--Keraobnskoye; 5, Atarskoye; 6, Kinskoye; 7, Uzel'-Zhal'skoye; 8, Uralbayskoye; 9, Mointinskoye; 10, Shumenskoye; 11, Zhamshinskoye; 12, Kounrad-Barlinskoye; 13, Zhusabyskoye; 14, Kurpetayskoye; 15, Aktasskoye; 16, Kyzylzhal'skoye; 17, Kyzylrayskoye; 18, Karshygalkinskoye; 19, Kentskoye; 20, Kazanchnskoye; 21, Central Kazakh; 22, Akbastauskoye; 23, Akzhal-Aksoranskoye; 24, Uspenskoye. II, Perm intrusives (1-Kyzyltauskiy); 2, Ortauskiy; 3, Zhaman-Karabsskiy; 4, Shaltasskiy; 5, Bektauatinskiy; 6, Kyzyltaskiy; 7, Kyzylrayskiy. 3, End cleavages.

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Translated for the National Aeronautics and Space Administration under Contract No. NASw-2485 by Techtran Corporation, P.O. Box 729, Glen Burnie, Maryland, 21061; translator, Orville E. Humphrey.